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I, JULIE BILLINGSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2004901167 for a patent by NAUTITECH PTY LTD as filed on 05 March 2004.

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Second day of August 2004

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AUSTRALIA

Patents Act 1990

Nautitech Pty Ltd

PROVISIONAL SPECIFICATION

Invention Title:

Transmission for marine craft

The invention is described in the following statement:

Field of the Invention

The present invention relates to a transmission for a marine craft. In particular, the invention relates to an automated manual transmission which is particularly suited for use in marine applications but may also be used in other applications, particularly where a compact transmission is desirable.

Background of the Invention

In most existing marine drives in watercraft, a marine engine is coupled to a propeller via a gear box which provides a single gear ratio. The speed of the watercraft is controlled by controlling the engine speed via a throttle. Generally speaking, watercraft are geared so that they run most efficiently at their intended cruising speed. A large yacht may be designed to cruise at 35 to 40 knots and is thus geared to be most efficient and controllable at or around that speed. However a problem with this arrangement is that such craft are very difficult to operate at the low speeds that may be required for example, when docking the craft. It is very difficult to dock a boat safely if, for example, the lowest speed that the boat will satisfactorily travel at, is around 10 knots. It is also, in some cases, desirable to have a low gear ratio for applications where increased torque is required, with a higher gear ratio for high speed operation.

Although a number of multi-speed drive transmissions have been proposed for watercraft, they suffer from a number of problems. For example, US 6,350,165 discloses a watercraft which incorporates a two forward speed plus one reverse speed transmission. The transmission is based on a planetary gear apparatus and is consequently relatively high cost. The transmission has a further problem in that because of the way the gearing is arranged, it is not possible to vary the gear ratios easily, since all the gear wheels must be changed. It is thus harder to package and adapt planetary gearing systems to suit different applications, engine sizes and the like.

A further problematic area with watercraft, concerns "torque interrupt". Torque interrupt occurs when a transmission system is temporarily disengaged when the gear ratio of the transmission system is changed. One common example of torque interrupt occurs when a driver changes gear in a motor vehicle. Whilst it is acceptable to have torque interrupt in a motor car, since the momentum of the vehicle will keep the vehicle moving during the period when the transmission is temporarily disengaged, in a watercraft, torque interrupt is a more serious problem because the drag on a watercraft's hull is much greater than the frictional drag on a motor vehicle and the watercraft is appreciably slowed during any period when the transmission is disengaged.

A further problem which occurs with watercraft, is "clunking" which occurs as a watercraft is put into forward or reverse gear. Whilst clunking is not a serious problem from an operational point of view, a person spending a large sum of money to buy a watercraft, particularly at the more expensive end of the market, might prefer a watercraft having a transmission system which does not "clunk" when the craft is put into gear.

One further issue which needs to be taken into account when designing marine drives, is the need for the drive to be compact and to fit into the space available on the watercraft for the marine drive and any marine transmissions should ideally, not take up substantially more space than existing single speed marine transmissions.

It is an object of the present invention to address or alleviate at least some of the problems of the prior art.

Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is solely for the purpose of providing a context for the present invention. It is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

Summary of the Invention

According to the present invention there is provided a compact two speed transmission system for a marine craft comprising:

an input shaft;

an output shaft,

a first gear train for connecting the input shaft to the output shaft for driving the same in a first gear;

a second gear train connecting the input shaft to the output shaft for driving the output shaft in a second gear; and

a clutch means for connecting the input shaft to the output shaft at a gear ratio other than one to one.

The output shaft and input shaft may be parallel and linked by gear trains for first and second gears.

Alternatively, the output shaft and input shaft may be co-axial and linked via a lay shaft extending parallel to the input and output shafts.

Preferably the gear trains are selected to provide a higher gearing i.e. faster spinning of the lay shaft when the second clutch is engaged although an opposite arrangement would be possible.

The transmission may be used in a watercraft particularly, but not exclusively in a stern drive unit.

In a preferred embodiment a one way clutch means is incorporated in the first gear train so that when second gear is engaged first gear over-runs.

The clutch means may be a friction clutch

A further friction clutch means connecting first gear to the output shaft may be provided.

The friction clutch or clutches may be located on the output shaft either between the first and second gears or with the first and second gears located between the clutches and the output end of the output shaft.

A control system may be provided for controlling the first and second clutches. Amongst other inputs, the control system may receive inputs from various sensors including clutch pressure sensors, sensors measuring the speed of the input shaft and output shafts respectively and sensors providing information relating to the position of gears in the gear trains.

One or more control valves and electro-hydraulic solenoids may be used to provide controlled clutch slip for docking and other functions where very low speeds of the order of a few knots may be desired.

The control system may also be used to control the solenoid to allow slipping of the clutch when initiating movement of the watercraft to avoid the problem of "clunking" as the boat is put into, or taken out of, gear.

Brief Description of the Drawings

A specific embodiment of the present invention will now be described by way of example only and with reference to the accompanying drawings in which:

Figure 1 is a schematic diagram of the stern of a watercraft having a bravo type stern drive transmission;

Figure 2 is a schematic diagram of a first stern drive transmission for the watercraft of Figure 1;

Figure 3 repeats the diagram of Figure 2 with a control system superposed on the diagram;

Figure 4 is a schematic diagram of a second stern drive transmission;

Figure 5 repeats the diagram of Figure 4 with a control system superposed on the diagram;

Figure 6 is a schematic diagram of the stern of a watercraft having a alpha type stern drive transmission;

Figure 7 is a schematic diagram of a two-speed transmission having a single clutch in which the output gears are located close to the output of the transmission;

Figure 8 shows a two-speed transmission with a single clutch in which the clutch is located close to the output;

Figure 9 shows a two-speed transmission with dual clutches with the output gears located at the output end of the shaft;

Figure 10 shows a two-speed transmission having two clutches on which the clutch is located near the output end of the transmission; and

Figure 11 illustrates the position of the transmission relative to a swim platform on a marine craft.

Detailed Description of a Preferred Embodiment

Referring to the drawings, Figure 1 shows the stern of a watercraft 10 having a hull 12. A stern drive unit 16 incorporating a dual clutch automated manual transmission 18 is located behind the transom 20 of the watercraft, an engine (not shown) is located inside the hull and an output shaft 22 from the engine projects generally horizontally from the stern of the watercraft and provides power to the stern drive unit 16. This type of marine propulsion system is also commonly referred to as an "inboard/outboard drive".

The output shaft of the watercraft 22 spins about a generally horizontal axis. A bevel gear 24 is fixed to the distal end of the output shaft. The bevel gear 24 defined at the end of the output shaft meshes with forward and reverse bevel gears 26, 28 respectively and a dog clutch 30 moves in the direction of arrow "A" to connect a vertical output shaft 32 with the forward bevel gear 26, or in the direction "B" to connect the vertical output shaft 32 with the reverse bevel gear 28. A lower part 34 of the vertical output shaft is operatively connected to a further pair of meshing bevel gears 36, 38 which convert the vertical axis movement of the output shaft 34 to a generally horizontal shaft 40 driving a propeller or propellers 42. The above arrangement is typical of existing marine stern drive systems and is commonly known by some companies as a "Bravo" drive. The present invention is concerned with a transmission system and control means which not only provide two speed drive for the

watercraft but also provide a number of other advantages over existing marine transmission systems.

Figure 2, shows a first transmission 18 embodying the present invention in more detail. Instead of being directly coupled to the lower bevel gear 36 as in most existing stern drives, the vertical output shaft 32 (which is the input shaft for the transmission 18) is connected via a first friction clutch pack 44 to a co-axial lower output shaft 46. When the first clutch is engaged the lower output shaft 46 spins at the same rate as the vertical output shaft 32. A second friction clutch pack 48 is also provided. When the second friction clutch pack is engaged, a lay shaft 56 is driven via components 52, 54 which in turn drives the lower output shaft 46 via gears 57 and 58. In the described embodiment, the gearing has been selected to provide a higher gearing i.e. faster spinning of the lower shaft 46 when the second clutch is engaged, however this is not necessarily the case in all embodiments and the gears may be used as overdrive or underdrive. Forward and reverse is still selected by the bevel gearing and dog clutch 30 at the head of the output shaft, so the system can provide two speeds in both forward and reverse directions.

A control system illustrated in Figure 3 is provided for controlling the dual clutches. The control system includes an electronic control unit (ECU) 60 linked to various sensors including sensors providing information to the ECU regarding the position/pressure of the clutches. The system also includes sensors 62 and 64 measuring the speed of the input shaft and output shafts respectively and sensors 66 providing information about the position of the gears, sensors 68 providing information about to the engine's throttle position, and sensors 70 providing information concerning to the temperature of the systems hydraulic fluid. Alternatively, some of this information can be collected off the common vessel/engine BUS or CAN.

Figure 3 also shows a valve body 80 containing a control valve and an electro-hydraulic solenoid 82 (more than one may be used) to activate controlled clutch slip as described in more detail below. The pressure of the solenoid 82 can also be fed to the ECU. Figure 3 also illustrates a hydraulic pump 84 used for maintaining hydraulic pressure in the system's hydraulic controls.

The control system is arranged to allow slipping of the clutch to avoid the problem of "clunking" as the boat is put into, or taken out of, gear. The dog clutch will engage the input shaft with either the forward or reverse bevel gear, and the output shaft disengaged. The control system is arranged to gradually apply the clutch using an electro-hydraulic solenoid to smoothly transfer power from the input shaft to the output shaft.

The system of clutch slipping may also be used for docking functions where very low speeds of the order of a few knots may be desired and wherein clutch slip may be used to dissipate excess rotational speed of the output shaft to allow slower movement of the boat whilst maintaining engine speed.

The problem of torque interrupt is overcome by operating the transmission so that the first clutch is disengaged simultaneously with the engagement of the second clutch and vice versa, when the boat is moving.

Figures 4 and 5 illustrate a variant 18a of the transmission of Figures 2 and 3. components which are common to both embodiments have the same reference numerals. In the transmission 18a a one way clutch 100 is provided between the lay shaft 56 and the input shaft 32. This gives the advantage of a smooth gearshift without having to time a clutch swap since the one way clutch will either grab or let go depending on which gear is selected. The disadvantage of this is that reverse gear may be operated in the lower gear only.

Figure 6 illustrates the system in use with an "alpha" type drive instead of the bravo drive shown in Figure 1. In this case the output shaft 24 is directly connected to input shaft 32 via bevel gears 24 and 28 and forward and reverse are provided at the lower end of the drive adjacent the propeller 40 selected via a dog clutch 120.

Although the system described above incorporates two wet clutches, it would be appreciated that dry clutches could also be substituted for the wet clutches.

Figure 7 shows a further embodiment of a marine transmission, in this case, a single clutch automated manual transmission 100. As in the case in the previously described transmission, this transmission is also shown as part of an inboard/outboard marine drive.

The output shaft of the watercraft, not shown, spins about a generally horizontal axis and is coaxial with and drives the input shaft 102 of the transmission which is mounted on bearings 103. The output shaft 104 of the marine transmission, is supported on bearings 105 parallel to and spaced from the input shaft 102.

A bevel gear 106 defined at the output end 104a of the output shaft 104 meshes with forward and reverse bevel gears 108, 110, respectively and a dog clutch 112 moves in a vertical direction to connect a vertical output shaft 114 with either the reverse bevel gear 110 or the forward bevel gear 108, or vice versa depending on whether a right hand or left hand propeller is fitted.

The selection of forward or reverse motion for the marine craft direction of the propeller is carried out by the dog clutch 112 after the output of the marine transmission and therefore the input and output shafts of the marine transmission,

always rotate in the same sense, and the transmission 100 is not required to cope with rotation of the input or output shafts in more than one direction.

As is standard in the art, a lower part of the vertical output shaft, not shown, is operatively connected to a further pair of meshing bevel gears, which convert the vertical axis movement of the vertical output shaft 114 to a generally horizontal axis movement of a horizontal shaft driving a propeller.

A gear wheel 120, for fist gear is mounted on the output shaft 104 and this in turn, meshes with gear wheel 122 incorporating a one-way clutch mounted on the input shaft 102. A gear wheel 124 for second gear and an associated clutch 126, is mounted on the output shaft adjacent the first gear and on the opposite side of first gear 120 to the output end 104a of the output shaft. The second gear meshes 124 with a gear wheel 128 mounted on the input shaft adjacent the one-way clutch 122.

When the clutch is not engaged, which is the default condition so that the marine craft is able to travel in first gear in the event of failure of the clutch, the input shaft drives the output shaft via first gear 120 which is used for docking and low speed manoeuvring. Gears rotate and slip occurs across first clutch pack. The main part of the clutch 126 rotates with the output shaft.

When the clutch 126 is engaged, second gear is engaged, and the clutch 126 and second gear turn with the output shaft. First gear 120 is forced to rotate at the same speed as the same angular speed as second gear 124 and the one-way clutch 122 over runs.

In contrast with existing marine transmissions it will be appreciated that it is a relatively simple matter to change gear ratios by simply replacing two gear wheels, or four gear wheels if both first and second ratios are to be changed (although second is normally 1::1).

A further advantage is that the drive requires only one clutch to provide the two different gears and can therefore be more compact.

Figure 8 shows a similar arrangement to that which is shown in Figure 7 except that in this arrangement the relative positions of the first 104 and second 126 gear wheels are reversed on the input and output shafts and the clutch is located adjacent the output end of the output shaft. This arrangement has the advantage that it makes the overall transmission shorter at the top, and helps to ensure that the transmission can clear the swim platform, as is discussed in more detail below with reference to Figure 11.

Figures 9 and 10 illustrate two-speed marine transmissions incorporating two clutches. As shown in Figure 9 the input shaft 150, again extends parallel to and is

spaced apart from the output shaft 152 and the output end 152a of the output shaft is again connected to a bevel gear and dog clutch arrangement for driving a boat's propeller via a vertical shaft, in a similar arrangement to what is described for the transmissions of Figures 7 and 8.

The input shaft 150 is connected to the output shaft 152 via first gear 154 and second gear 156. First gear meshes with gear wheel 158 which includes a one-way clutch. Second gear 156 meshes with gear wheel 160. Friction clutch packs 162 and 164 are provided for engaging second and first gears respectively.

When second gear is engaged using clutch 162, the one-way clutch over runs and first gear 154 simply spins. In second gear, the first gear and the clutch associated with the first gear, do not rotate so that there is no drag in second gear which is the gear used most of the time.

This arrangement provides a number of advantages over existing marine drives including such as are described above in connection with the embodiments shown in Figures 1 to 6 by using electro-pneumatic solenoids to control the friction clutch packs. The arrangement is not counter rotational sensitive since the forward and reverse choice is made after the end of the output shaft 152a.

An alternative arrangement is shown in Figure 10. In this version, the two clutch packs are located on the opposite side of the gears, in between the gears and the output of the output shaft. This arrangement makes the overall transmission shorter at the top. When the stern drive is not in use, it is raised out of the water, but there is a swim platform that the drive must clear. This design being shorter at the top axis allows more room for clearing the swim platform. Turning to Figure 11, the transmission and propeller assembly 200 may be lifted out of the water by rotating the assembly in a clockwise direction, indicated by arrow A. The top of the assembly 202 moves towards the rear of the boat and the rear 204 moves towards the swim platform 206. The shorter the transmission is, the less likely it is to interfere with the swim platform.

Also, the one way clutch is provided on the first gear 154 on the output shaft rather than the meshing gear wheel 158 on the input shaft. With this arrangement, the output shaft will rotate faster in second and them over run the one way clutch at the differential speed of the first gear ratio.

Further, although the system is described as being incorporated in the stern drive unit of an inboard/outboard marine propulsion system, it will be appreciated that the system could also be incorporated in outboard systems where the engine and transmission systems are all located behind the transom due to its compact size and

light weight. It could also be used in variations of shaft drive and v-drive marine propulsion systems between the engine and the propeller.

The transmission may also be used in non-marine applications where size, cost and weight are an issue such as in fork-lift transmissions.

It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

Dated this fifth day of March 2004

Nautitech Pty Ltd
Patent Attorneys for the Applicant:

F B RICE & CO

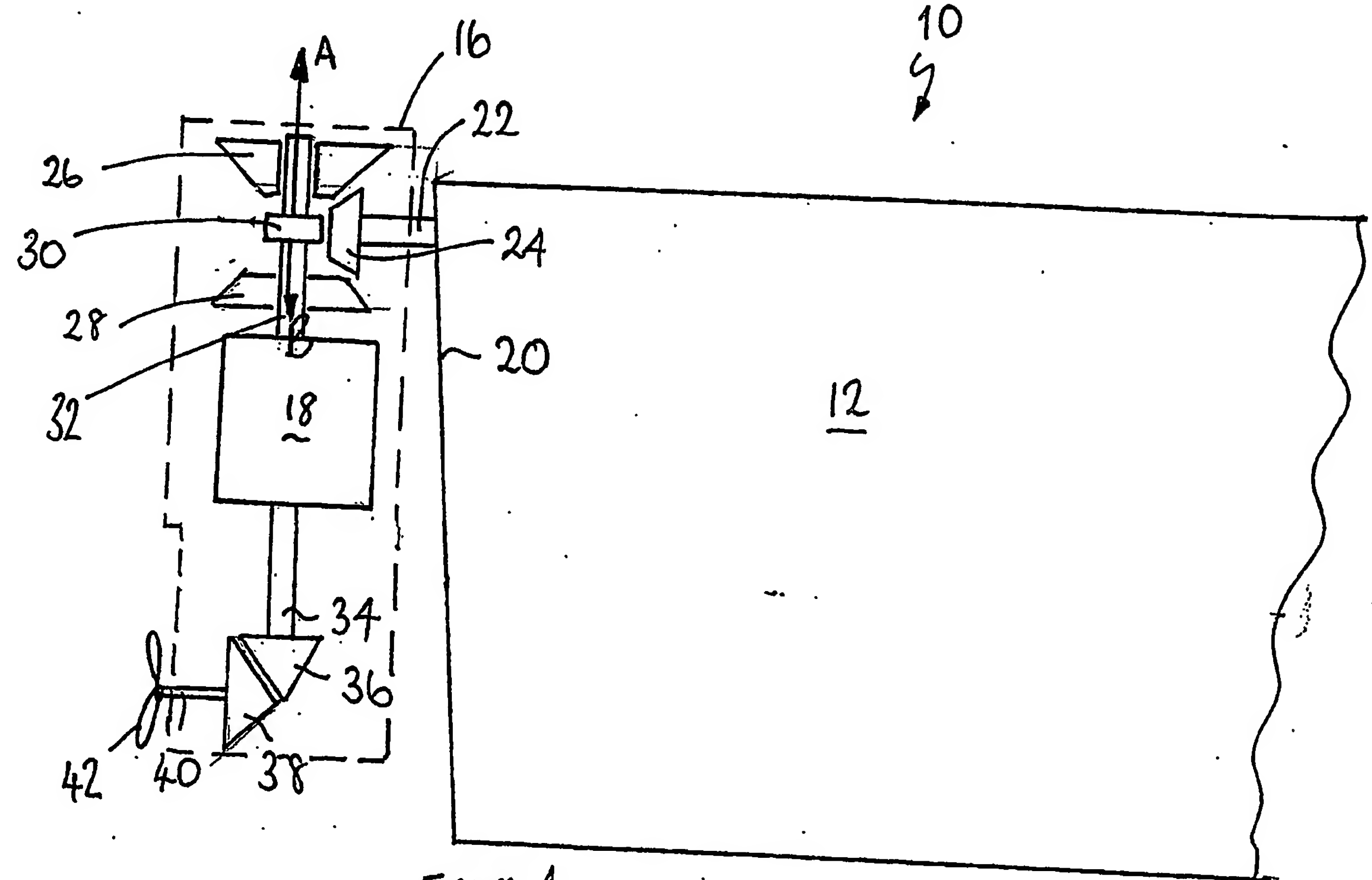


Figure 1

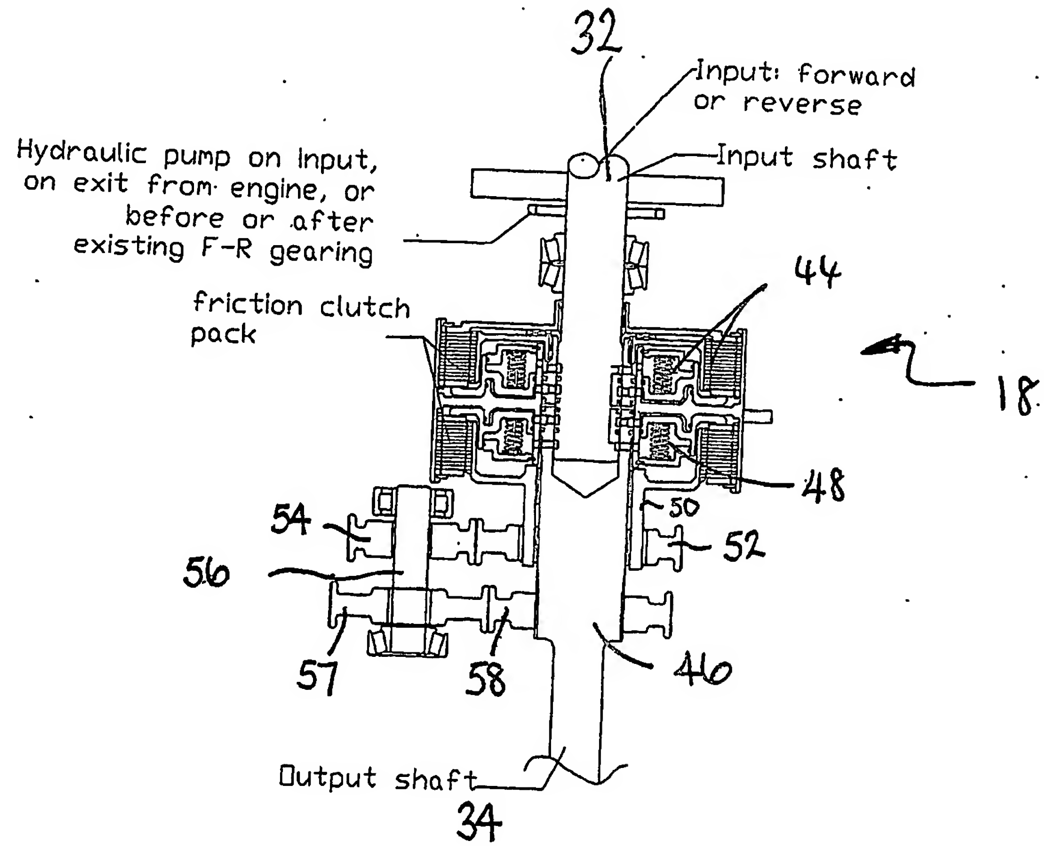

32
Input: forward or reverse
Input shaft
Hydraulic pump on Input, on exit from engine, or before or after existing F-R gearing
44
friction clutch pack
18
48
50
54
52
56
57
58
46
Output shaft
34

Figure 2

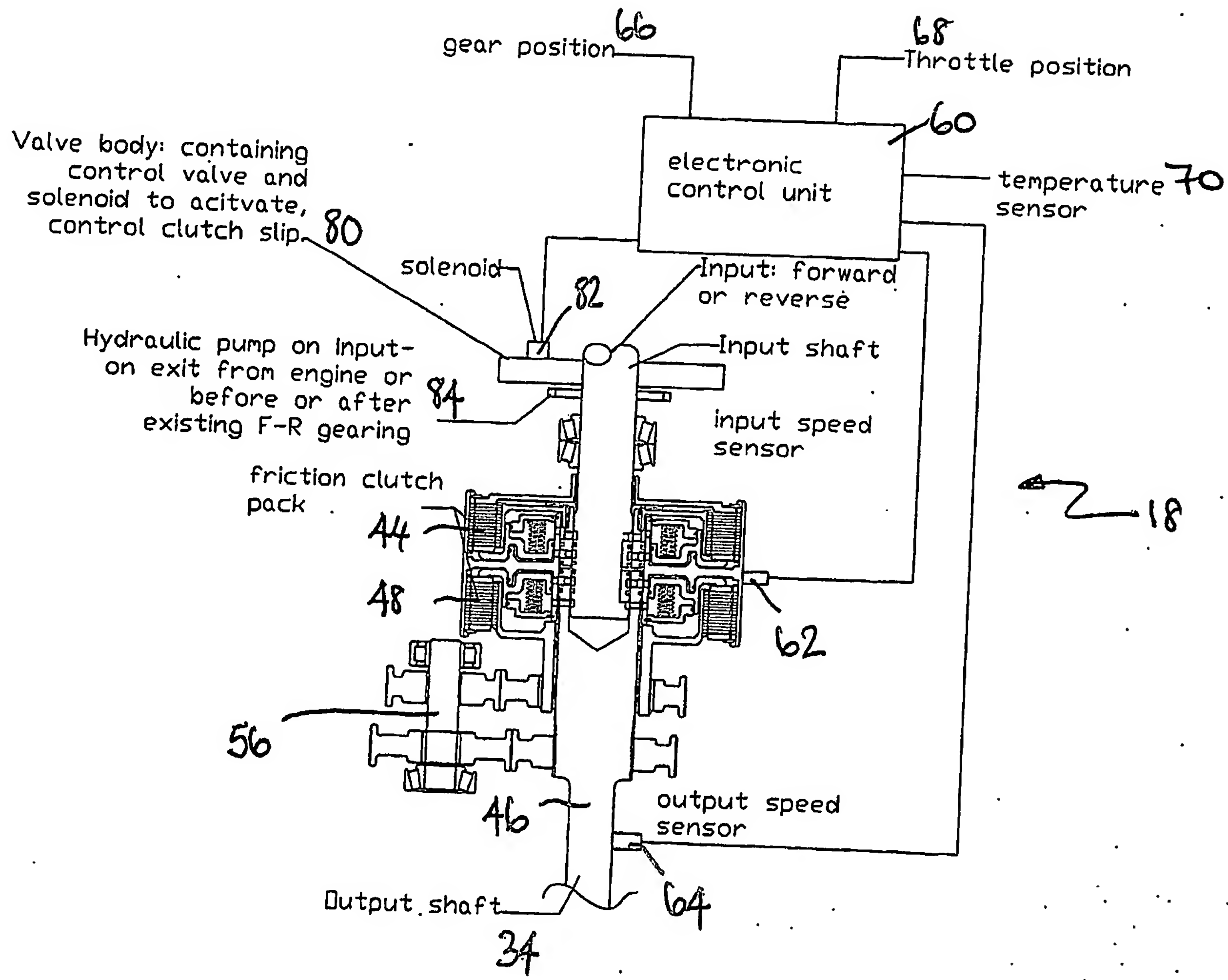

gear position 66
68 Throttle position
60
electronic control unit
temperature sensor 70
Valve body: containing control valve and solenoid to acitvate, control clutch slip 80
solenoid
82
Input: forward or reverse
Input shaft
Hydraulic pump on Input- on exit from engine or before or after existing F-R gearing
84
input speed sensor
friction clutch pack
44
48
18
62
56
46
output speed sensor
Output shaft
64
34

Figure 3

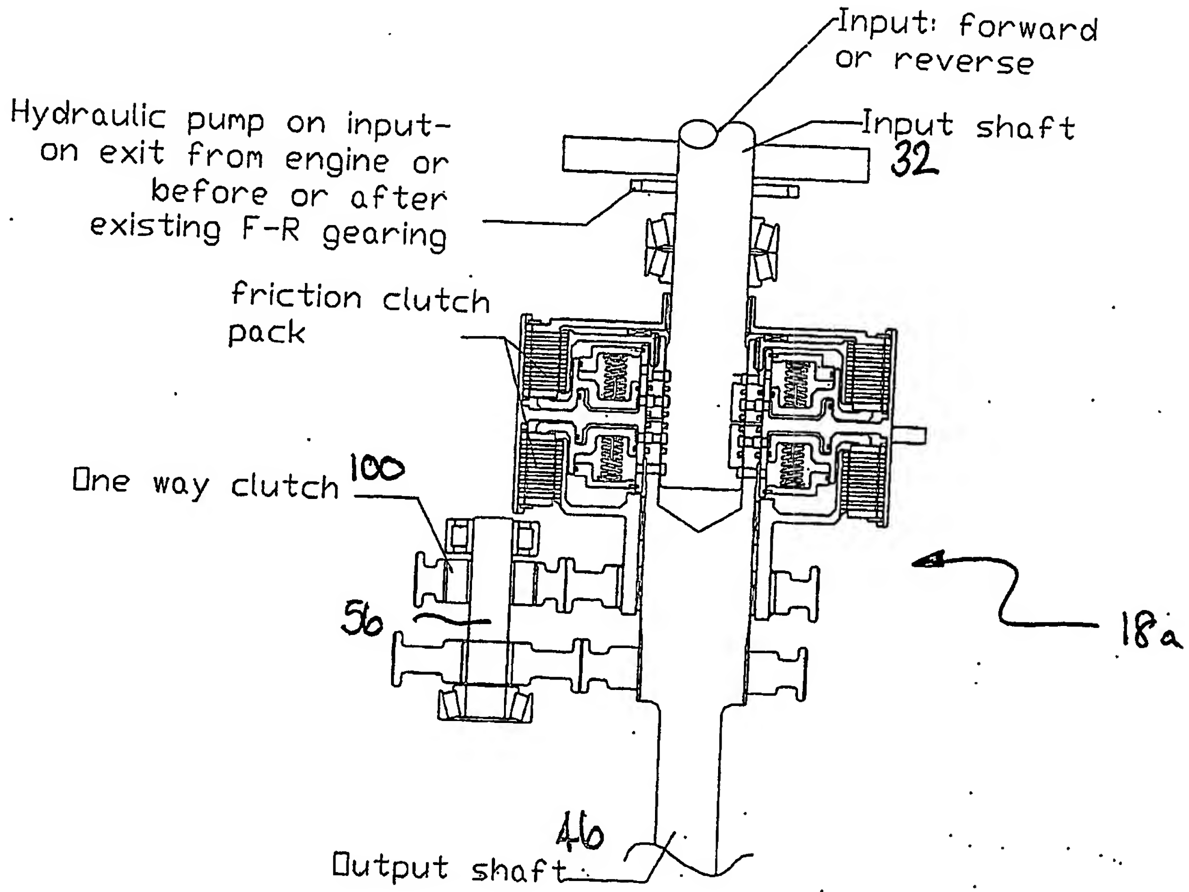

Input: forward
or reverse
Input shaft
32
Hydraulic pump on input-
on exit from engine or
before or after
existing F-R gearing
friction clutch
pack
One way clutch
100
56
18a
46
Output shaft

Figure 4

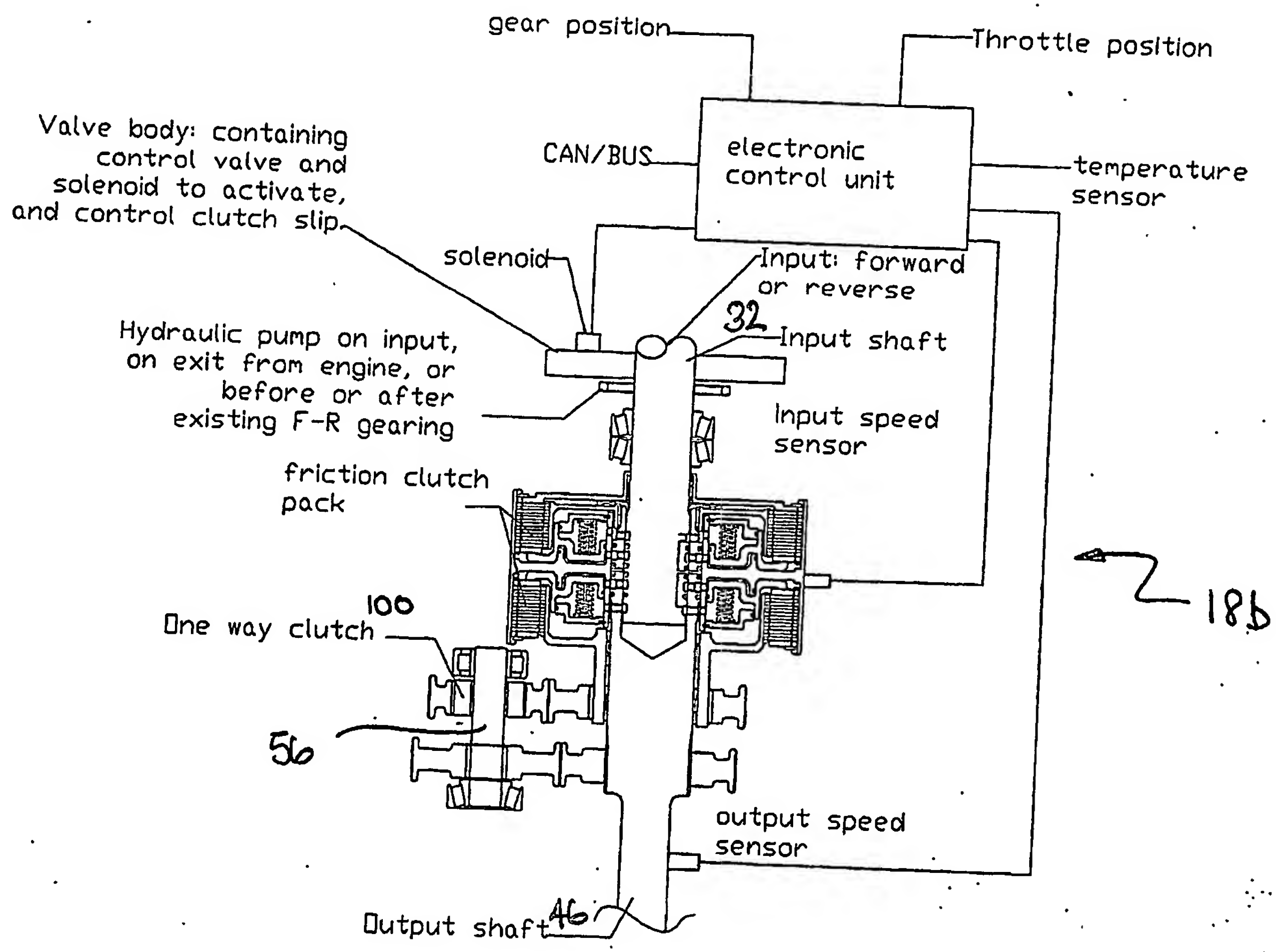

gear position
Throttle position
electronic control unit
CAN/BUS
temperature sensor
Valve body: containing control valve and solenoid to activate, and control clutch slip
solenoid
Input: forward or reverse
32
Input shaft
Hydraulic pump on input, on exit from engine, or before or after existing F-R gearing
Input speed sensor
friction clutch pack
100
One way clutch
18b
56
output speed sensor
Output shaft
46

Figure 5

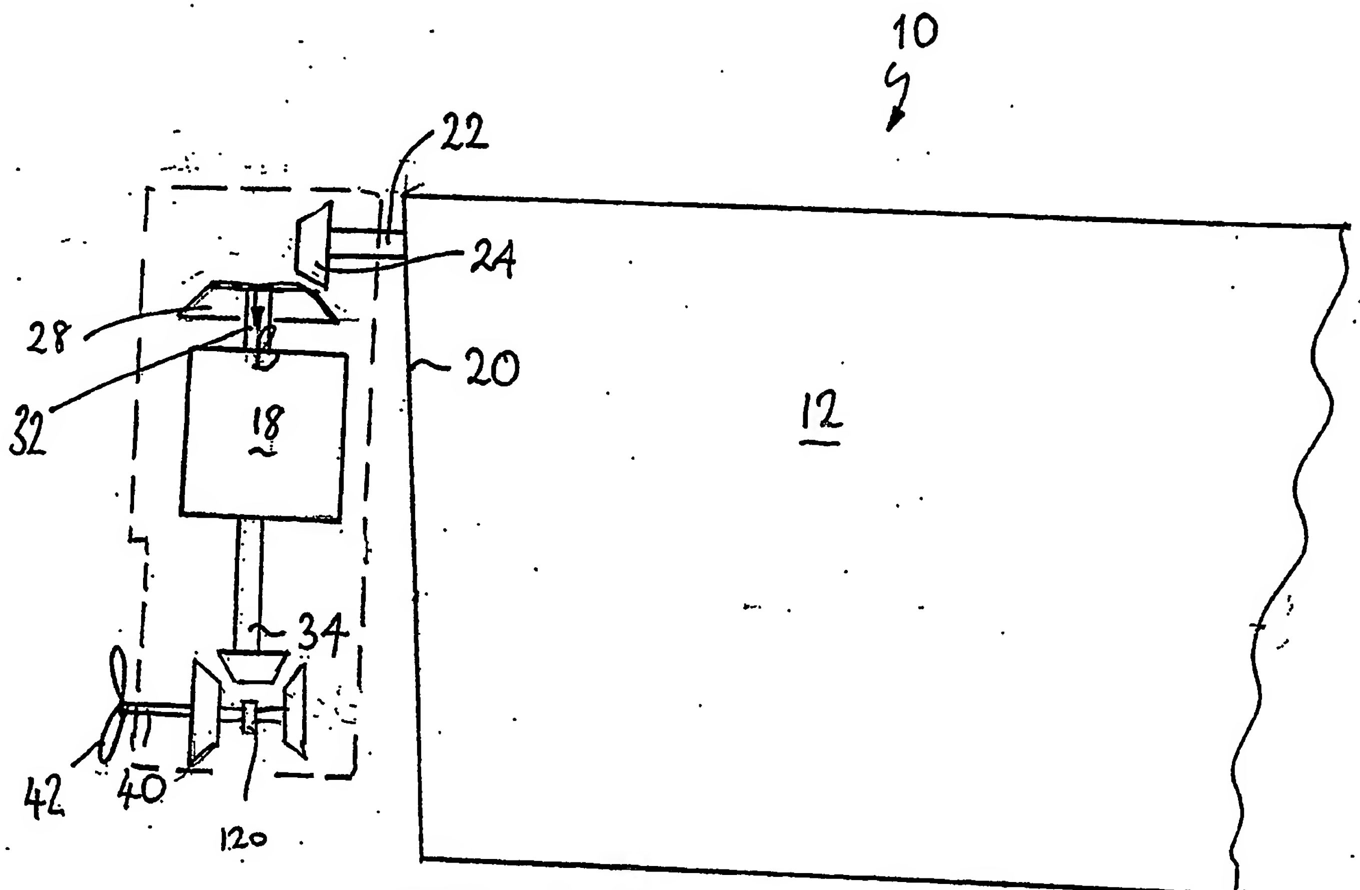
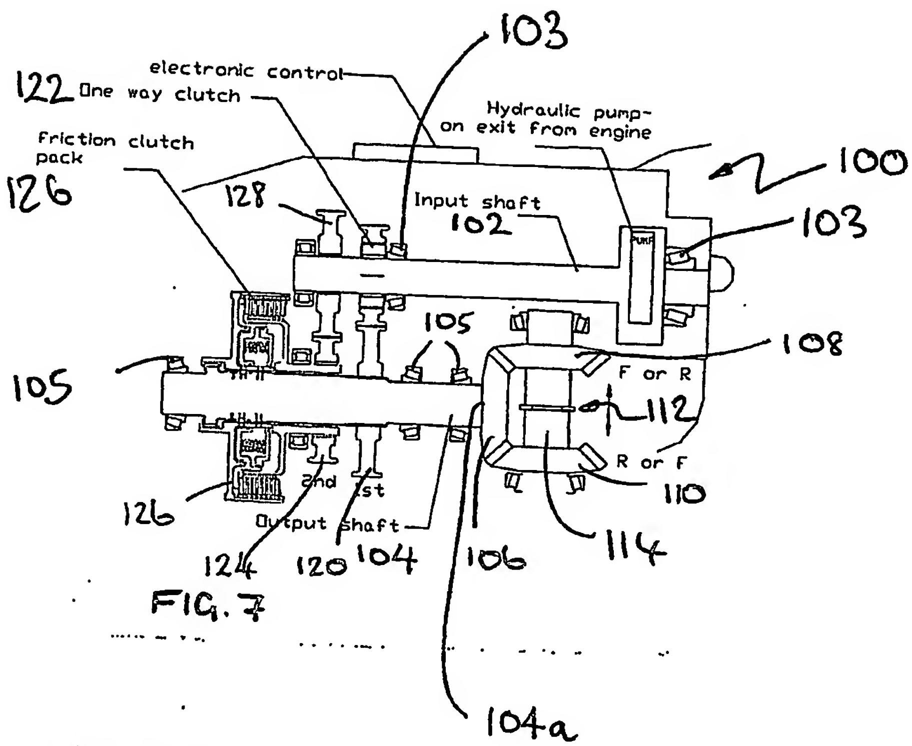
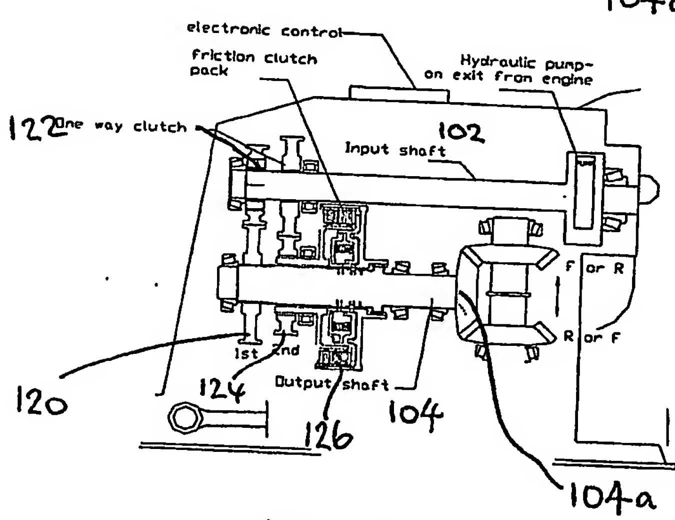


Figure 6


103
electronic control
122 One way clutch
Hydraulic pump-
on exit from engine
Friction clutch
pack
100
126
128
Input shaft
102
103
105
108
105
F or R
112
R or F
110
126
2nd
1st
Output shaft
114
124
120
104
106
104a
FIG. 7


electronic control
Friction clutch
pack
Hydraulic pump-
on exit from engine
122 One way clutch
102
Input shaft
F or R
R or F
1st
2nd
120
124
Output shaft
104
126
104a
FIG. 8

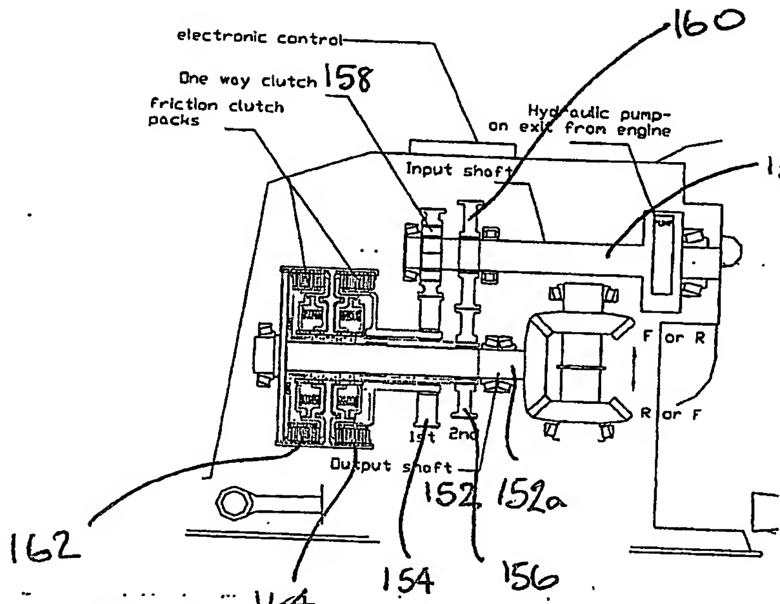

160
electronic control
One way clutch 158
friction clutch packs
Hydraulic pump-on exit from engine
Input shaft
150
F or R
R or F
1st
2nd
Output shaft
152
152a
162
164
154
156

FIG. 9

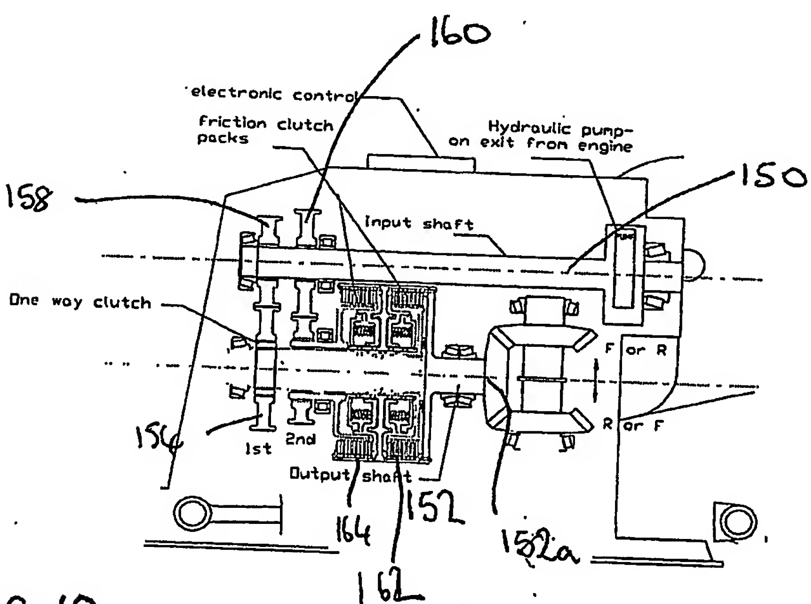
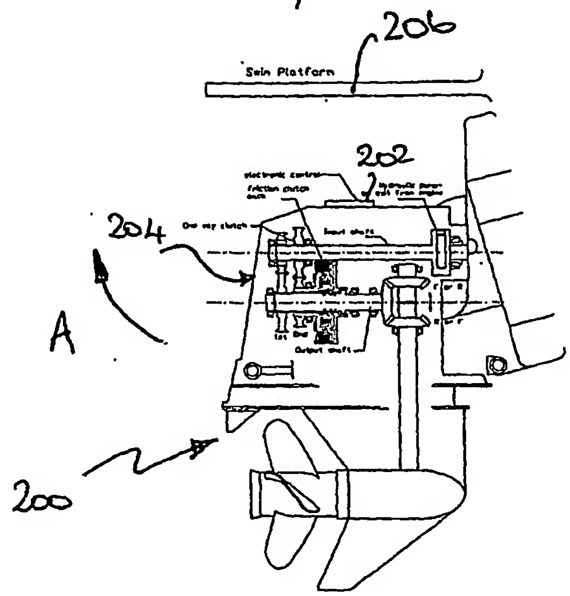

160
electronic control
friction clutch packs
Hydraulic pump-on exit from engine
150
158
Input shaft
One way clutch
F or R
R or F
156
1st
2nd
Output shaft
152
164
152a
162

FIG. 10



206
Swim Platform
202
electronic control
204
One way clutch
Input shaft
1st
2nd
Output shaft
A
200

FIG. 11